

OBSERVATION OF THE FLUXES OF NUCLEI WITH ENERGIES 10-20 MEV  
PER NUCLEON DURING THE SOLAR FLARE OF APRIL 26, 1984

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ABSTRACT

Observations of the fluxes of low energy nuclei in the Earth's magnetosphere are reported. The energy distribution and the composition of the nuclear component of cosmic rays observed during the Solar flare of April 26, 1984 are presented.

I. Introduction. The nuclei (C,N,O) with energies 5-10 MeV per nucleon at altitudes 350-450 km within  $-52^\circ < \lambda < 52^\circ$  were observed on the Skylab (1973-1974) and Salyut-6 (1981) scientific orbital stations [1, 2]. The question now is what is the origin of these particles.

Indeed, the magnetic rigidity of the nuclei is so small that the Earth's magnetic field inhibits the access of these nuclei to the noted latitude from the interplanetary space. The assumption [1] that the observed particles are the singly charged ions which are "stripped" at the altitudes of hundreds of kms and trapped by the earth magnetic field seems to us unsound because the carbon ion  $C^+$  with an energy of 5 MeV per nucleon will have the rigidity 1.2 GV and can be trapped on the shell with  $L \geq 3.5$  only. At the altitudes 350-450 km within the latitudes  $\pm 52^\circ$  there are no regions where the particles trapped at  $L \geq 3.5$  could be observed.

The assumption that the observed particles are the nuclei accelerated in the magnetosphere and accumulated in the internal Earth radiation belt [3] is not obvious either. The fact is that at the noted altitudes the maximum of the intensity of the trapped particles corresponds to  $L = 1.2 - 1.5$ . If the particles are accelerated while radial drifting from the more

removed L-shells to  $L=1.2-1.5$ , they will fail to reach the observing level, because of the low drift velocity they lose the total energy to ionization in the residual atmosphere at heights of 400-700 km. The assumption that the particles are accelerated at the observed altitudes would imply the existence of an unknown acceleration mechanism.

The consideration of the situation led us to the assumption that there are short-time periods when the radial drift velocity is by several orders of magnitude higher than that of mean one typical for small L. During these short-time periods the particles could jump from  $L = 2$  to  $L = 1.2$  without energy losses. This assumption leads inevitably to the consequence on strong intensity variations of the flux of low energy nuclei observed at low altitudes near the Earth.

2. Methods. To obtain the information on the stability of the fluxes we regularly exposed small stacks of solid detectors to the near-earth space. The stacks consisted of several 100 mkm cellulose nitrate sheets. The area of the stacks was  $10-20 \text{ cm}^2$ . The stacks were wrapped about with two Al mylar layers, each 5 mkm in thickness.

3. Results and discussion. The results of observations during the 1984 year are presented in Table I.

Table I.

No. of the stack	Exposure time	Angle of in- clina- tion of orbit	Mean height	Flux of nuclei (C,N,O): $\text{cm}^{-2}\text{day}^{-1}$	Notes
I	April-May 1984	$72.9^\circ$	400 km	$\sim 2000$	Solar flare
2	June 1984	$72.8^\circ$	400 km	$1.3^{+0.1}$	
3	June-July 1984	$62^\circ$	260 km	$2.4^{+0.2}$	
4	September-October 1984	$70^\circ$	400 km	$15^{+1.0}$	
"Salyut-6"	May 1981	$52^\circ$	350 km	$\sim 200$	Solar flare

The fluxes of nuclei in the 5th column refer to the particles coming to rest in the upper layer of the stacks. The 1981-year data are given in the last line of the Table. It is seen from the Table that during the 1981-1984 year period the flux of nuclei at the Earth magnetosphere at heights of  $\sim 300$  km changed by a factor of  $\sim 10^2$ . During the 1984 year the flux also varied (the data from the stacks No. 2, 3, and 4).

We failed to identify the charges of nuclei registered in the stack No.2 and No.3 because their paths were small. The spectra of particles stopping in the top sheet of these stacks were, therefore, identified from their total ranges on the assumption that all the nuclei registered are the oxygen ones. The obtained spectra are presented in Fig. 1 and 2. Typical is a very "soft" spectrum such as

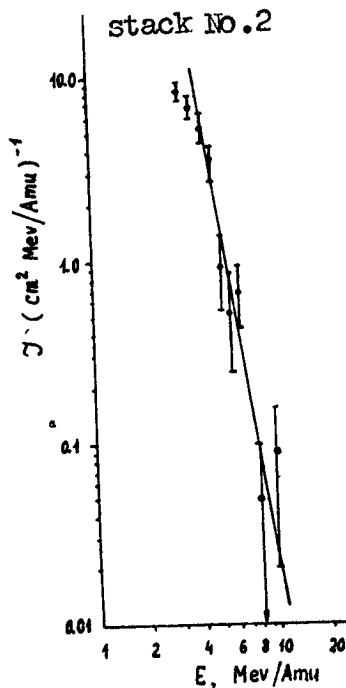


Fig. 1

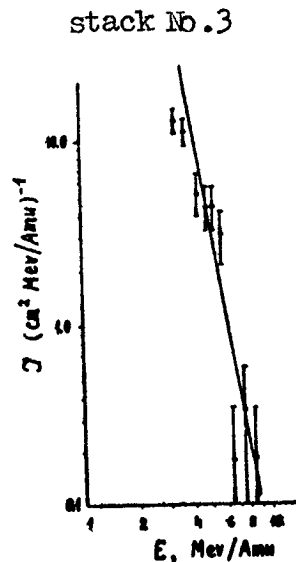


Fig. 2

$I(E) \sim E^{-\gamma}$  with  $\gamma \simeq 6$ . It is similar in shape to the spectrum of the particles observed in the Earth's magnetosphere on the Salyut-6 station, but the flux intensities differ sharply. The bending of the

spectrum at  $E < 4$  MeV per nucleon is due to the threshold effect.

In April 1984 the exposure time of the stack No. I coincided with a powerful solar flare. The particles observed in the stack

No. I are seemingly the particles from the flare detected during the short-time periods when the satellite (inclination to the equatorial plane  $\sim 73^\circ$ ) arrived into the region with a low rigidity of the magnetic cut-off. The charge identification was made from the dependence of the etched cone length on the residual range. The energy of the nuclei with a known charge was determined from the total path in the stack. Fig. 3 presents the energy spectrum of C and O nuclei observed during the flare. It will be noted that both flare particles and nuclei observed in the magnetosphere have the same energy distribution (large  $\gamma$ ).

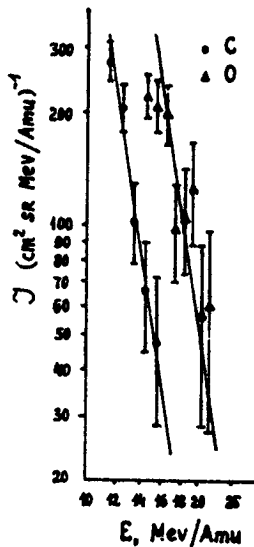


Fig. 3

4. Conclusions. In order to contribute to an increased understanding of the nature of low energy nuclei at low altitudes near the Earth it is necessary to obtain information on the spatial distribution of the observed fluxes.

#### References.

1. Biswas, S., Durgaprasad, N., Nevatia, J., and Venkatavaradan, V.S., (1975), Proc. 14th ICRC, 2, 816.
2. Bobrovskaya, V.V., Gorchakov, E.V., Grigorov, N.I. et al., (1983), Proc. 18th ICRC, 2, 2.
3. Chan, J.H., and Price, P.B., (1975), Proc. 14th ICRC, 2, 831.